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The objective of the research program was development of computer vision techniques for experimental soil micromechanics and for characterization of soils, both in the laboratory and in-situ. for micormechanics research, a particle tracking system, consisting of state-of-the-art hardware and developed software tools, was assembled for monitoring the kinematics of particulate assemblies undergoing large strain deformations and flow. The utility if this system, the testing methodologies and the suite of developed applications: flow of soil through an orifice at the base of a container; the plowing of soil off of a plain strain embankment and the development of shear bands in soil around an advancing ribbed inclusion. The major demonstrated use for this system was in verification of discrete element models with particular focus on the development of strain localization and shear banding.

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for support of Scott A. Raschke,
Ph.D. Candidate
at the
University of Michigan
Ann Arbor, Michigan

Experimental Micromechanics of Geomaterials Through Computer Visualization

University of Michigan
Report No. UMCEE 96-25

submitted by

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October 30, 1996

Introduction

The present report includes a summary of work conducted under AFOSR Grant No. DAAH04-95-1-0227. This three-year AASERT Grant to the University of Michigan supported the research efforts of Scott A. Raschke, culminating in his anticipated award of a Doctor of Philosophy in Civil Engineering in December, 1996. Various components of the study also benefited from the following sources of funds:

"Interface Mechanics of Particulate Media With Ribbed Inclusions"
AFOSR Grant No. F49620-92-J-0216 (the parent grant)

"Computer Vision for Large Deformations in Particulate Media"
Army Research Office Grant DAAH04-95-1-0227

"Subsurface Vision Probe Development"
NSF Grant CMS-9510301

"Computer Vision Instrumentation for Continuous Soil Profiling"
Defense University Research Instrumentation Program
(DURIP Grant No. DOD-G-DAAH04-95-1-0574)

Dr. Raschke's dissertation is attached with this report. It is the most complete technical document acknowledging support under the AASERT grant. The following sections summarize the major accomplishments of the study and the technical publications resulting from the grant

Summary of Research Accomplishments

SF-298 Abstract

The objective of the research program was development of computer vision techniques for experimental soil micromechanics and for characterization of soils, both in the laboratory and in-situ. For micromechanics research, a particle tracking system, consisting of state-of-the-art hardware and developed software tools, was assembled for monitoring the kinematics of particulate assemblies undergoing large strain deformations and flow. The utility if this system, the testing methodologies and the suite of developed computer vision programs that were developed was demonstrated in three different applications: flow of soil through an orifice at the base of a container; the plowing of soil off of a plain strain embankment and the development of shear bands in soil around an advancing ribbed inclusion. The major demonstrated use for this system was in verification of discrete element models with particular focus on the development of strain localization and shear banding.

In soil characterization, a laboratory testing system was developed for rapidly and accurately determining the grain size distribution of cohesionless soils (gravels to silts) from a series of digital images take at various magnifications. Corrections for statistical bias were developed and excellent agreement was observed with grain size distributions obtained by conventional sieving. The final component of the study involved the design, construction and testing of an in-situ vision probe. The probe, which can be used in

conjunction with standard electronic cone penetrometers, captures subsurface images of the soil at two magnifications. The images may be digitized for subsequent computer vision analysis to determine grain size distributions. Just as importantly, the vision probe unambiguously provides information regarding the locations of interfaces between dissimilar soils and the thicknesses of even very thin anomalous soil lenses.

Technical Publications Acknowledging AFOSR Grant No. DAAH04-95-1-0227:

Raschke, S.A. and Hryciw, R. D. (1996) "Soil Grain Size Distribution by Computer Vision" submitted to the ASTM Geotechnical Testing Journal, in review.

Hryciw, R. D., Raschke, S. A., Ghalib, A. M., Horner, D. A. and Peters, J. F. (1996) "Video Tracking of Experimental Validation of Discrete Element Simulations of Large Discontinuous Deformations", accepted for publication in Computers and Geotechnics.

Raschke, S.A. and Hryciw, R.D. (1996) "Micro-Deformations in Sands by Digital Image Processing and Analysis" accepted for publication in Transportation Research Record.

Hryciw, R.D. and Raschke, S.A. and (1996) "In-situ Soil Exploration Using Computer Vision" Transportation Research Record, No. 1526 pp. 86-97.

Hryciw, R.D. and Raschke, S.A. (1994) "Visualization Needs for Soil Characterization in Geotechnical earthquake Engineering" Proceedings of and NSF Workshop on Scientific Supercomputing, Visualization and Animation in Geotechnical Earthquake Engineering and Engineering Seismology, Carnegie-Mellon University, Nov. 12-13, 1994

Planned publication:

Hryciw, R. D. , Raschke, S. A, and Ghalib, A. M. (1996) "The Vision Cone Penetration (V-CPT) System" abstract submitted to the First International Conference on Site Characterization, Atlanta, GA., 1998